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Biosecurity in the new bioeconomy

Editorial overview

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Andy Sheppard is currently the Theme Leader of CSIRO's Biodiversity Research Theme which undertakes research to build resilience into Australia's biodiversity assets and includes overarching responsibility of Australia's National Herbarium, the Australian National Insect Collection and the Australian Mammal Collection. He was Theme Leader of CSIRO's Theme 'Invasive Species and Plant Biosecurity' from 2006 to 2010 which paralleled a science career in CSIRO in invasive plant management and biological control, understanding plant invasions through intercontinental ecological comparisons. He has adjunct positions at both the Australian National University and Charles Sturt University and has served on the Governing Body of the OECD Cooperative Research Program.

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S. Raghu is currently a Research Scientist within CSIRO Ecosystem Sciences, and is a member of the USDA-ARS Australian Biological Control Laboratory. His research focuses on using ecological and evolutionary knowledge to facilitate better natural resource management outcomes. Much of his current research is on the ecology and management of invasive plants and insects, and the sustainable management of agricultural and natural systems. He has worked in tropical, temperate and arid systems in both the developing and the developed worlds. He holds an adjunct position with the Illinois Natural History Survey, University of Illinois.

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Cameron Begley was appointed to the position of General Manager, Business Development and Commercialisation at CSIRO Entomology in 2005. In this role he oversees a broad portfolio of research areas, balanced between commercial and public benefit research. He is involved in developing commercial partnerships and opportunities around industrial biotechnology and the broader opportunities emerging within the bio-based economy. This includes current research activities such as crop biofactories, development of input traits for transgenic crops, bio-remediation enzymes and bio-refinery technology platforms. He was also the chair of the CSIRO Bioeconomy Strategy Development Working Group.

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David M. Richardson is Professor in the Department of Botany & Zoology at Stellenbosch University, South Africa, and is Deputy Director: Science Strategy at the DST-NRF Centre of Excellence for Invasion Biology. His field of research is invasion ecology, and in particular the ecology and management of woody plant invasions. He was awarded the 2006 Hans Sigrist Prize for his work on biological invasions. Dave is a Fellow of the Royal Society of South Africa, Member of the Academy of Science of South Africa, and since 1998 has been Editor-in-Chief of the international journal Diversity and Distributions (Wiley-Blackwell). He is editor of the book Fifty Years of Invasion Ecology. The legacy of Charles Elton (2010, Wiley-Blackwell).

This 2011 Terrestrial systems issue of *Current Opinion in Environmental Sustainability* discusses the new bioeconomy (which the OECD considers has the potential of generating a 21st century agricultural revolution [1]) with respect to the associated biosecurity and sustainability issues that will emerge within it. The Bioeconomy includes all economic activities relating to the invention, development and production of particularly non-food products and processes based on biological resources. It is largely driven by a future need for industrial products and fuels to be derived from renewable resources and therefore largely from biological production systems in agro-forestry. By biosecurity we are referring to biological threats to the integrity of such biological resources and the environment. The biosecurity concerns this issue discusses relate to addressing the agricultural, environmental and some human health risks of developing, trialling, distributing and cultivating new crop species where the potential economic and particularly sustainability benefits are still largely unknown. These risks are associated with the unaided spread of these new crops themselves and the economic risks posed by pests to these future production systems [2]. Production systems that from competition with food-based agriculture will by necessity need to be more viable on the less fertile parts of the landscape. The issue provides industrial, scientific and policy perspectives.

In the introductory paper Andy Sheppard *et al.* review the environmental and agricultural sustainability issues of biofuel and other non-food crops in the new global bioeconomy and the international policy opportunities and challenges for sustainable development. The first group of three papers broadly focuses on the sustainability aspects of the bioeconomy within the specific context of the chemical industry (Jean-Luc DuBois) and the biofuel industry (S. Raghu *et al.*, and Uffe Jørgensen). Jean-Luc DuBois explains the drivers, the risks and the developing solutions from within the chemical industry for embracing new production systems from renewable biological resources. He also introduces some of the associated human health risks around toxins and allergens. S. Raghu *et al.* present and explore some of the key ecological and environmental challenges facing the biofuels industry and argue that the associated biological complexities will need multidimensional and cross-disciplinary solutions. Uffe Jørgensen looks specifically at one of the first new temperate crop species being developed for the biofuels industry, namely the C4 perennial grass *Miscanthus*, and the associated biosecurity risks and issues that need to be addressed for its sustainable production.

The second group of five papers have a science focus and look at the direct biosecurity threat of plant invasions resulting from the cosmopolitan spread and widespread cultivation of new crops. Mark Lonsdale and Frances Fitzgibbon explore why a science-based prediction of which potential future

crops will become biological invaders is theoretically difficult and support a precautionary risk monitoring approach for the bioeconomy based on a scaling up process of new biofuel cropping systems supported by regular benefit analyses. In contrast, Dave Richardson and Ryan Blanchard look at this issue from the perspective of learning from our mistakes, reviewing historically introduced forestry species. Keith Ferdinands *et al.* push the discussion further by presenting the role and refinements needed in existing weed risk management systems associated with the policy needs to achieve a more sustainable and defensible approach to cultivating new alien plants. Margaret Byrne and Lynley Stone add to this by arguing for an industry focused 'duty of care' risk management framework for introducing new crops for agriculture, which should also include site hygiene protocols and genetic risk assessment of potential undesirable genetic transfer to other species. Tim Low *et al.* point out that the desirable characteristics of new crops, that is, fast growth, high yield and a capacity to grow under poor conditions also reflect the attributes of invasive species. They argue for better policy and regulatory control of new crop introductions because any future cleanup costs of feral crops will continue to be borne by the public purse. They explain why past voluntary approaches have failed. Several authors in this section argue for greater consideration of cultivating native species as future biomass sources, particularly for bio-energy needs, to get around some of the biosecurity issues.

This leads nicely into the third group of two papers which look more directly at the policy and regulatory issues around invasion threats from new crop species. Bill Roberts *et al.* work as regulators in government and describe and review the existing weed risk assessment system they developed and implemented in Australia and which is now increasingly being used by regulators in many countries around the world. They accept its scientific limitations, but more interestingly discuss how its effectiveness is also related to the level of societal and political risk aversion in any given jurisdiction. They go on to suggest how such regulatory processes will need to adapt to avoid blockage in the future importation demands likely with the development of the bioeconomy. Piero Genovesi describes how the EU has ambitious biofuel targets and it is also a community where the perceptions of benefits from the free flow of biological resources still outweigh that of invasion risks from new organisms. As such the EU poses a challenging political environment for the initiation of common policy processes against biological invasions, but progress is being made.

The second half of the issue focuses on the new and emerging pest management imperatives associated with the growing Bioeconomy. The fourth group of four papers considers the sustainable pest management challenges in bio-energy cropping systems looking at practicalities. Gary Fitt reviews how far pre-emptive landscape scale integrated insect pest management systems have developed for food and fibre crops, but argues such systems may prove too costly if new crops like biofuels are grown on marginal land which generate only low profits. This leads to a risk of reactive high pesticide responses to pest outbreaks with associated negative impacts on the environment. Genetic manipulation may offer solutions but he argues that the challenge will be to integrate new crop pest management approaches into the existing agricultural landscapes without causing disruptions. Alison Stewart and Matthew Cromey view the risks to the future bioeconomy from plant diseases and argue that such risks have largely been ignored to the industries' peril in the push to market new production systems. They review a range of recent disease management approaches that can be applied to sustainably protect such crops from significant losses to diseases. This section finishes with two in depth looks at existing production systems at the forefront of the Bioeconomy. First, François-Régis Goebel and Nader Sallam review the global sugarcane industry where the challenges of balancing cane production for food versus fuel markets have become very acute. From a pest impact perspective, management options are already mature, but the threats of global spread of key sugarcane pests could still cripple the industry. Second, Armand Séguin reviews recent advances in plantation forestry research relevant to sustainable bio-energy production and carbon sequestration. He considers the industrial challenges posed by lignin and the potential scientific solutions including GM in also developing viable pest management solutions.

The finally two papers consider new paradigms for managing new pests. Linda Thomson and Ary Hoffmann consider our capacity to predict future pests based on distribution modelling and through assessing the status of pests on related existing crops, but warn of the capacity for pests harboured by new crops to complicate the pest management status of existing successful pest management approaches like biological control. Tony Ives and Nancy Schellhorn suggest that poor research investment in understanding such future pest impacts will lead to often counterintuitive but significant harmful pest interactions and outbreaks. They then argue that R&D investments need to be strategically focussed on quite simple pest management models that are showing themselves to be more reliable for understanding likely outcomes than large complex simulation models. They warn against investing to try to attain accurate prediction while being in favour of suggesting potential future scenarios and using theory to assess how these might pan out.

This issue finishes with a synthesis paper by Andy Sheppard *et al.* that presents the discussions of two public forums during a recent international *Biosecurity in the New*

Bioeconomy summit all the authors in this issue attended in Canberra Australia supported by the OECD and CSIRO. Their paper also reflects on the thoughts from two workshops on the future R&D and Policy needs for biosecurity in the new bioeconomy It finishes by presenting series of recommendations and considerations that came out of the summit suggesting how the relevant industries, scientists and policy makers can work together more effectively to ensure the Bioeconomy can develop in developed and developing countries without exacerbating the environmental degradation that has resulted from agriculture and forestry in the past. The guest editorial committee hope that this issue provides both a comprehensive and valuable set of views on the biosecurity needs of future agroforestry industries.

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